

## Level 1C Version 07 (V07) Release Notes

This Level 1C Version 07 (V07) release involves the following changes from the previous release in the GPM radiometer constellation.

1. A new parameter, “sunLocalTime” (local solar time), was added to all GPM V07 Level 1C products.
2. Level 1C V07 GMI brightness temperature (Tc) remains unchanged from V05. There is no GMI calibration update. A minor update was implemented to handle long-term failure of cold load and/or hot load.
3. Level 1C V07 TMI intercalibrated brightness temperature (Tc) differs from V05 by as much as 0.7 K due to the following updates:
  - a. Updated emissive reflector correction in L1B/1Base. V07 corrects a minor error discovered in the V05 emissive reflector correction and improves the simulated brightness temperatures used in the correction algorithm with ERA5 inputs instead of GDAS.
  - b. Adjusted first pixel time in L1B/1Base. This changes the geolocation by about 0.95 kilometers forward along-track for the 10 GHz channels and 0.15 km back along-track for the 19-85 GHz channels.
  - c. Updated intercalibration adjustments (XCAL2021-V) to account for the brightness temperature changes. Table adjustments range from 0.1 to 0.2 K depending on channel.
4. Level 1C V07 SSMIS intercalibrated brightness temperature (Tc) differs from V05 as shown in Table 3 and Figure 1 in Appendix A due to the following key improvements:
  - a. Updated geolocation. V05 included time-dependent spacecraft roll, pitch, and yaw values derived using ascending-descending brightness temperature coastline shifts and constant sensor roll, pitch, yaw, and half-cone angle values for each feedhorn. V07 set the spacecraft attitude values to zero and derived constant sensor offsets for roll and pitch using cross-track scan biases and offsets for yaw, half-cone angle, and timing using the coastline shifts. See Table 1 and Table 2 in Appendix A for these numbers.
  - b. Updated scan bias correction. The correction includes a scene temperature dependent correction that accounts for edge-of-scan obstructions.
  - c. Updated sun angle correction. This is the primary source of the brightness temperature differences between V05 and V07. This correction accounts for the emissive reflector on F16 and F17 and other heating anomalies like warm-load solar intrusion. The previous correction for V05 was developed over a decade ago and only adjusted the 19-91 GHz channels since the double difference with TMI was used as part of the correction. The F17 150-183 GHz channels were adjusted later for V05 but did not correct the F16 and F18 150-183 GHz channels. The sun angle correction developed for V07 adjusts all channels for F16, F17, and F18, except for the F18 150h channel, and includes the intercalibration to GMI as part of the correction. F19

does not have a sun angle correction since it appears to not have an emissive reflector or other significant heating anomalies.

- d. Updated intercalibration adjustments (XCAL2021-V). F16, F17, and F18 XCAL2021-V tables contain zeros since the intercalibration was included in the sun angle correction. F19 does not have a sun angle correction so the intercalibration is performed with the table. The F19 XCAL2021-V table was modified slightly from XCAL2016-V to account for changes in earth incidence angle due to geolocation updates.
- e. Improved quality control procedures.

Details on the calibration updates are described in Kroodsma, R. A., W. Berg, and T. T. Wilheit, 2022: Special Sensor Microwave Imager/Sounder Updates for the Global Precipitation Measurement V07 Data Suite, *IEEE Trans. Geosci. Remote Sens.*, doi:10.1109/TGRS.2022.3162529.

- 5. The input data to V07 MHS Level 1C products have changed from MSPPS ORB to TOVS L1B binary product due to the retirement of MSPPS. The maximum brightness temperature (Tb) change due to the input switch is less than 0.07 K. The MHS Level 1C data ranges have been extended with more early mission data. Based on the X-CAL team's recommendation, NOAA19 (from start to 2009-06-16) and METOP-A (from start to 2007-06-24) early mission data have been flagged as "caution" for possible calibration issues. In addition, The NOAA19 and METOP-A intercalibration have been updated to version XCAL2021-V. New intercalibration adjustments have been added and used for these early mission data. For the remainder of NOAA19 and METOP-B data and other MHS satellites (NOAA18, METOP-B, and METOP-C), the intercalibration adjustments remain unchanged from V05.
- 6. The input data to V07 Level 1C AMSRE have been changed from Version 3 L1B to Version 4 L1B data. The brightness temperature (Tb) change due to the input switch is typically within +/- 0.5 K with maximum up to 1 K. However, the mean Tb change is very small. As a result, the intercalibration adjustments remain unchanged from V05. The new Version 4 AMSRE L1B input data have wider swath width. As a result, the number of pixels per scan in the Level 1C AMSRE product has been increased from 196 to 243 in low-frequency channels and from 392 to 486 in high-frequency channels. Based on the X-CAL team's analysis, there is an end-of-scan blockage issue in the 10 GHz channels. Therefore, near-edge pixels (from 209th to 243rd pixels) have been flagged as "caution."
- 7. The input data to V07 Level 1C ATMS NPP have been changed from V1 SDR to V2 SDR data. The V1 SDR dataset had gone through a series of calibration updates that have caused inconsistencies in time series. The V2 SDR dataset (reprocessed by NOAA from 2011-11-08 up to 2019-10-15, the date that the last SDR calibration update was implemented) has unified and consistent calibration. The V07 ATMS NPP intercalibrated brightness temperature (Tc) differs from V05 as shown in Figure 1 and Figure 2 in Appendix B due to the input SDR dataset change. The V2 SDR dataset includes scene temperature dependent changes as well as cross-track scan bias adjustments, and this

accounts for the differences we see in the Tc between V05 and V07. For data after 2019-10-15, V07 Tc remain unchanged from V05.

For ATMS NOAA20, the V07 Level 1C brightness temperatures (Tc) remain unchanged from V05.

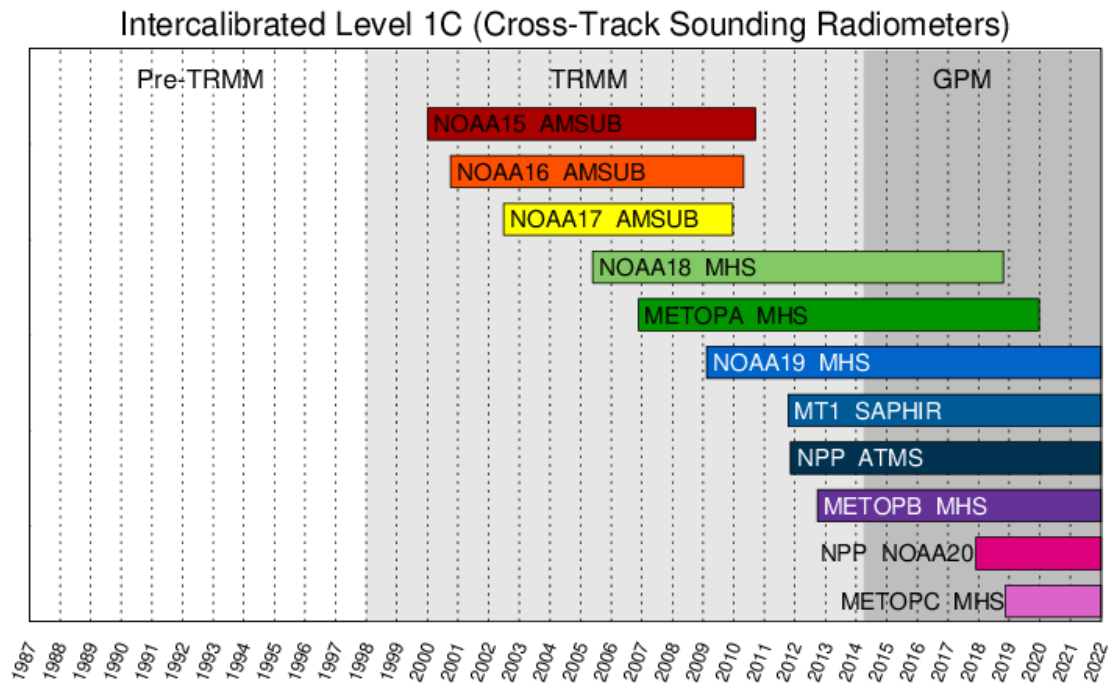
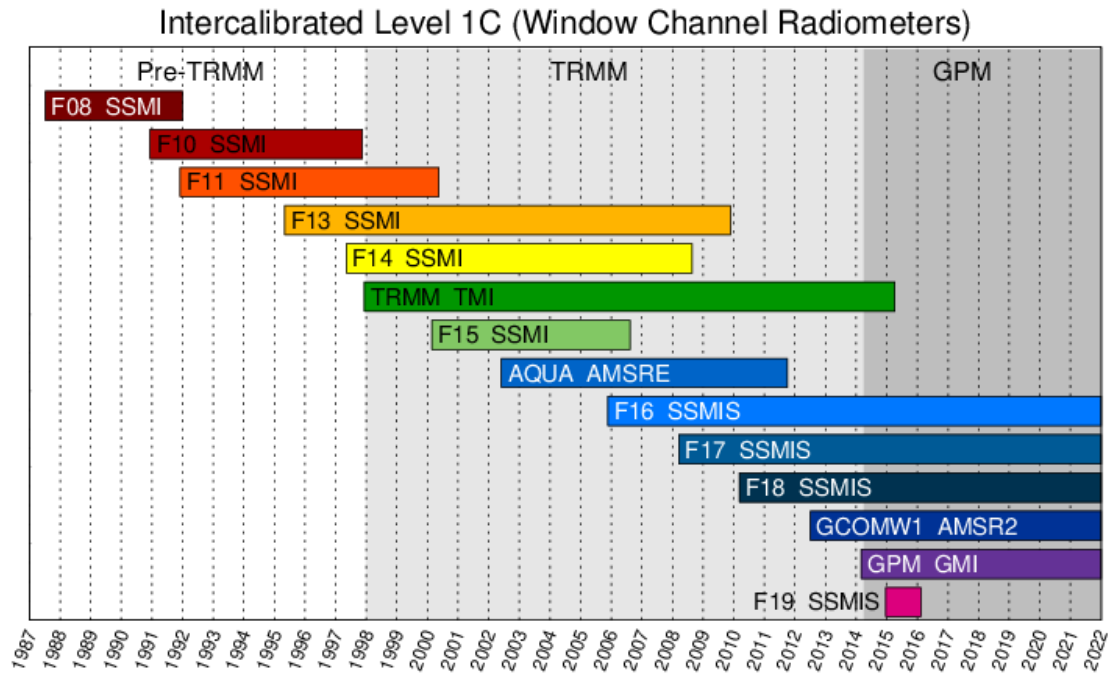
8. For other partner radiometers (AMSR2, SAPHIR, SSMI, and AMSUB), the intercalibrated brightness temperature (Tc) data remain unchanged from V05 (V06 for SSMI). However, minor updates such as improved quality control and better handling with erroneous scan-time data have been implemented in V07.
9. Based on the X-CAL team's recommendation, some data have been flagged as "bad" or "caution" in the V07 Level 1C product due to poor data quality, sensor issues, or failure.

Sensor	Channel	Start Date (Orbit)	End Date (Orbit)	Flag	L1C Tc
SSMIS F16	150 H	20150501 (59504)	20150810 (60944)	Bad	Set to missing
	183 +/- 1,3,7 H	20131031 (51776)	20150902 (61269)	Bad	Set to missing
	91 V,H	20150424 (59413)	20150902 (61269)	Bad	Set to missing
SSMIS F17	37 V	20160405 (48595)	20160518 (49201)	Bad	Set to missing
	37 V	20160803 (50286)	Ongoing	Bad	Set to missing
SSMIS F18	150 H	20120214 (11988)	Ongoing	Bad	Set to missing
MHS NOAA-19	All	Beginning	20090616 (1839)	Caution*	
MHS METOP-A	All	Beginning	20070624 (3527)	Caution*	
AMSU-B NOAA-15	89	20090101 (55297)	End	Bad	Set to missing
	183+/-1	20090101 (55297)	End	Bad	Set to missing
	183+/-3	Beginning	End	Bad	Set to missing
	183+/-7	20090101 (55297)	End	Bad	Set to missing
AMSU-B NOAA-16	183 +/- 1,3,7	20080101 (37503)	End	Bad	Set to missing
AMSRE AQUA	89A V,H	20040630 (11481)	End	Bad	Set to missing
	10 V,H	Beginning	End	Caution** (209 <sup>th</sup> to 243 <sup>rd</sup> pixels only)	
SSMIS F08	85 V	19890114 (8118)	End	Bad	Set to missing
	85 H	19910207 (18758)	End	Bad	Set to missing

\* Caution – Possible calibration issue.

\*\* Caution – End-of-scan blockage issue.

10. Level 1C data availability for Version 07 GPM constellation.



## Appendix A. SSMIS Level 1C V07 Release Notes

The following table shows the roll, pitch, yaw, and half-cone angle offsets used in V07 L1C SSMIS. The second table below shows the timing offsets used for each sensor and the date where the timing offset is changed. The timing offset is not channel dependent.

**Table 1.** The Roll, Pitch, Yaw, and Half-Cone Angle Offsets Used in V07 L1C SSMIS

	<b>Roll</b>	<b>Pitch</b>	<b>Yaw</b>	<b>Half Cone</b>
<b>F16</b> (env1: 19v/h, 22v)	0.14	0.16	0.20	0.61
<b>F16</b> (env2: 37v/h)	0.08	0.09	0.26	0.23
<b>F16</b> (img1: 150, 183)	0.00	0.00	0.15	-0.11
<b>F16</b> (img2: 91v/h)	0.11	0.31	0.31	0.22
<b>F17</b> (env1)	-0.03	0.08	0.19	0.25
<b>F17</b> (env2)	-0.02	0.03	0.32	0.17
<b>F17</b> (img1)	0.00	0.00	0.36	-0.33
<b>F17</b> (img2)	-0.08	0.26	0.21	-0.02
<b>F18</b> (env1)	0.17	0.06	-0.42	0.34
<b>F18</b> (env2)	0.11	0.13	-0.62	0.34
<b>F18</b> (img1)	0.00	0.00	-0.57	-0.10
<b>F18</b> (img2)	0.15	0.25	-0.31	0.19
<b>F19</b> (env1)	0.00	0.14	-0.50	0.07
<b>F19</b> (env2)	-0.06	0.09	-0.76	0.20
<b>F19</b> (img1)	0.00	0.00	-0.57	-0.35
<b>F19</b> (img2)	-0.04	0.17	-0.60	-0.25

**Table 2.** The Timing Offsets Used in V07 L1C SSMIS

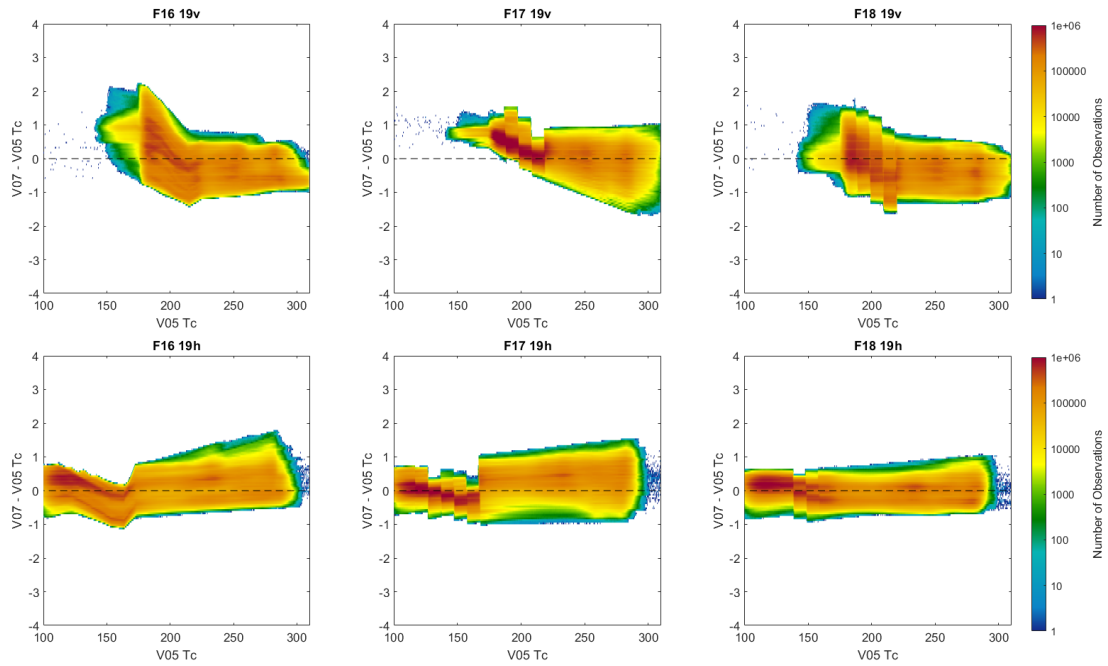
<b>Timing Offset (s)</b>	<b>Pre-2011</b>	<b>Post-2011</b>	<b>Date of Change</b>
<b>F16</b>	-0.25	0.50	Oct. 6, 2011
<b>F17</b>	-0.20	0.30	Jul. 28, 2011
<b>F18</b>	-0.40	0.50	May 15, 2011
<b>F19</b>	N/A	0.25	N/A

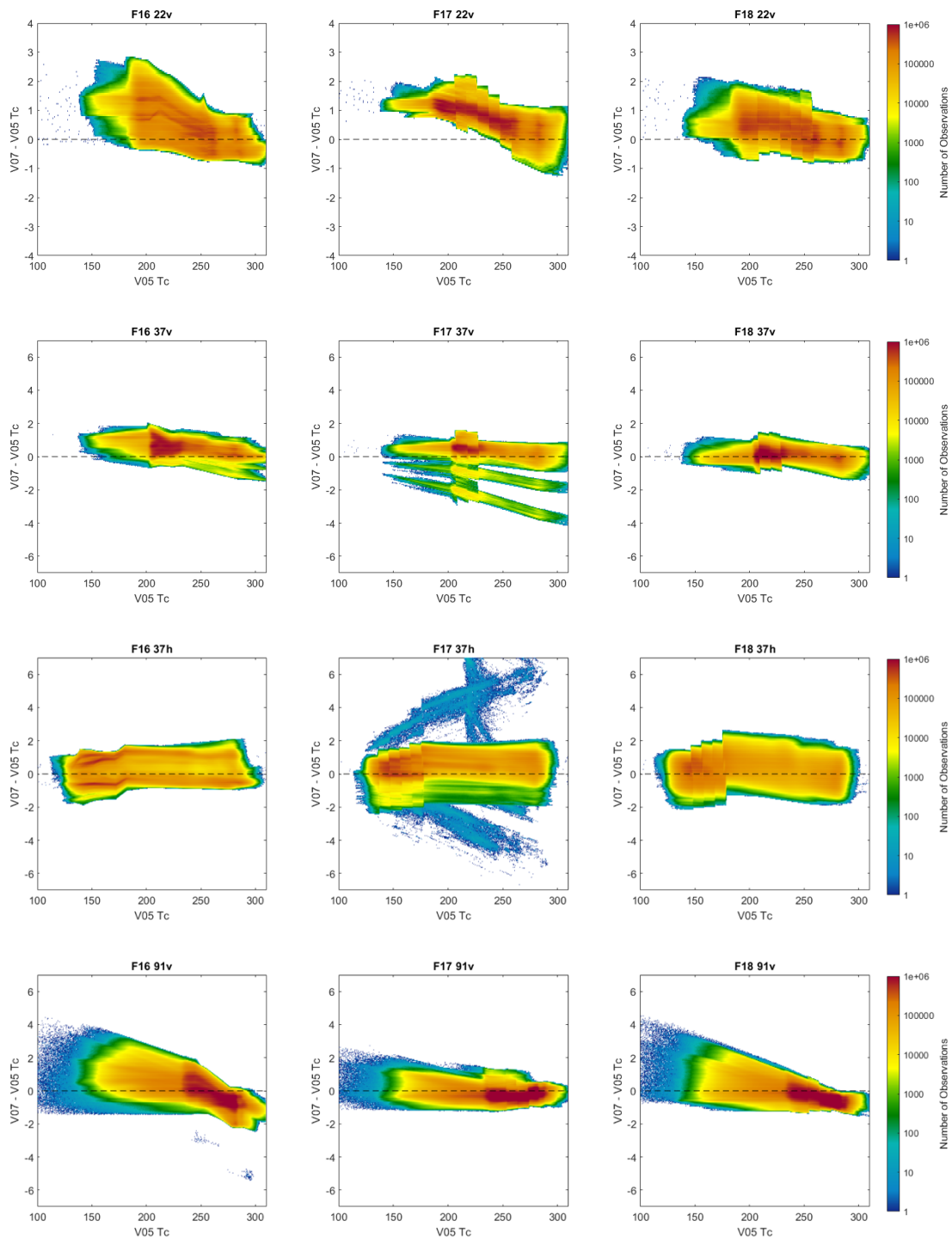
The following table shows the L1C SSMIS mean Tc difference V07 – V05 for one year of observations (2015 for F19, 2016 for F16, F17, and F18).

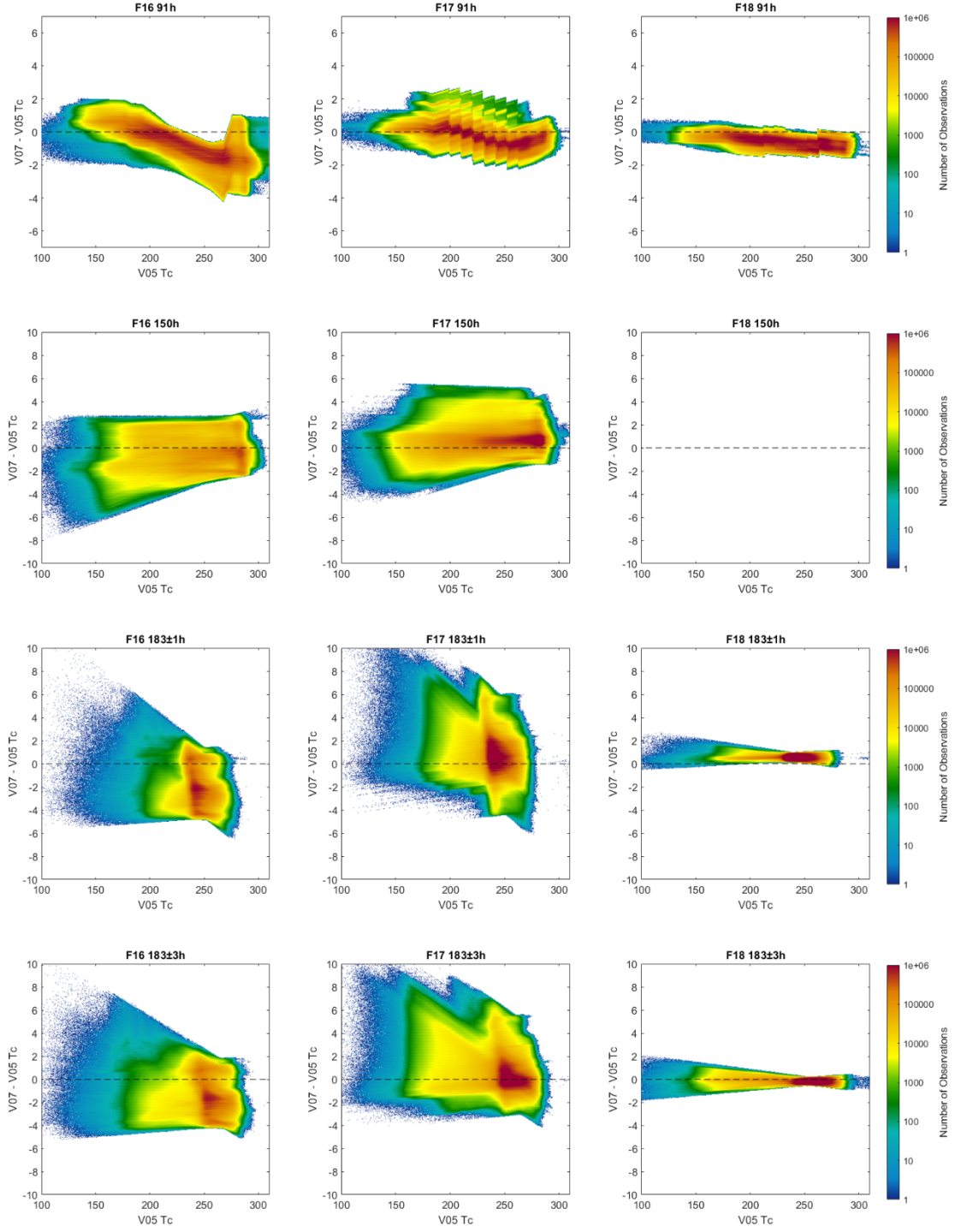
**Table 2.** L1C SSMIS Mean Tc Difference V07 – V05 for One Year of Observations

	<b>F16</b>	<b>F17</b>	<b>F18</b>	<b>F19</b>
<b>19v</b>	-0.10	0.20	-0.23	-0.27
<b>19h</b>	0.03	0.09	-0.01	0.12
<b>22v</b>	0.45	0.73	0.33	0.14
<b>37v</b>	0.54	0.34	0.08	-0.12
<b>37h</b>	0.23	0.48	0.25	0.14
<b>91v</b>	-0.11	-0.27	-0.32	-0.22
<b>91h</b>	-0.87	-0.36	-0.65	-0.39
<b>150h</b>	-0.51	0.61	N/A	0.26
<b>183±1h</b>	-2.15	0.61	0.51	0.36
<b>183±3h</b>	-1.61	0.20	-0.22	0.23
<b>183±7h</b>	-0.80	0.30	-0.15	0.33

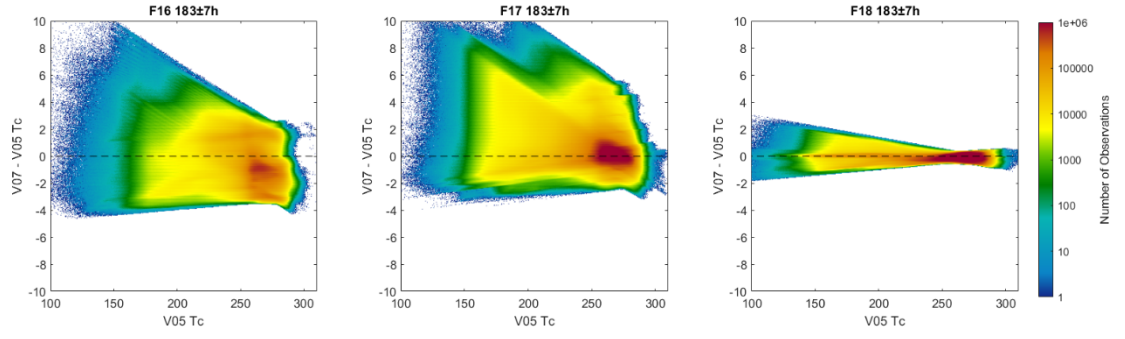
The following figure shows the difference between V07 and V05 Tc as a function of scene temperature. The sun angle correction is a function of both the sun position relative to the spacecraft (sun elevation and azimuth angles) as well as the observed scene temperature. The pronounced “steps” noticed in F17 and F18 are a result of the V05 sun angle correction being applied in 10 K increments, whereas V07 has a continuous correction as a function of temperature, which gives a smooth result.







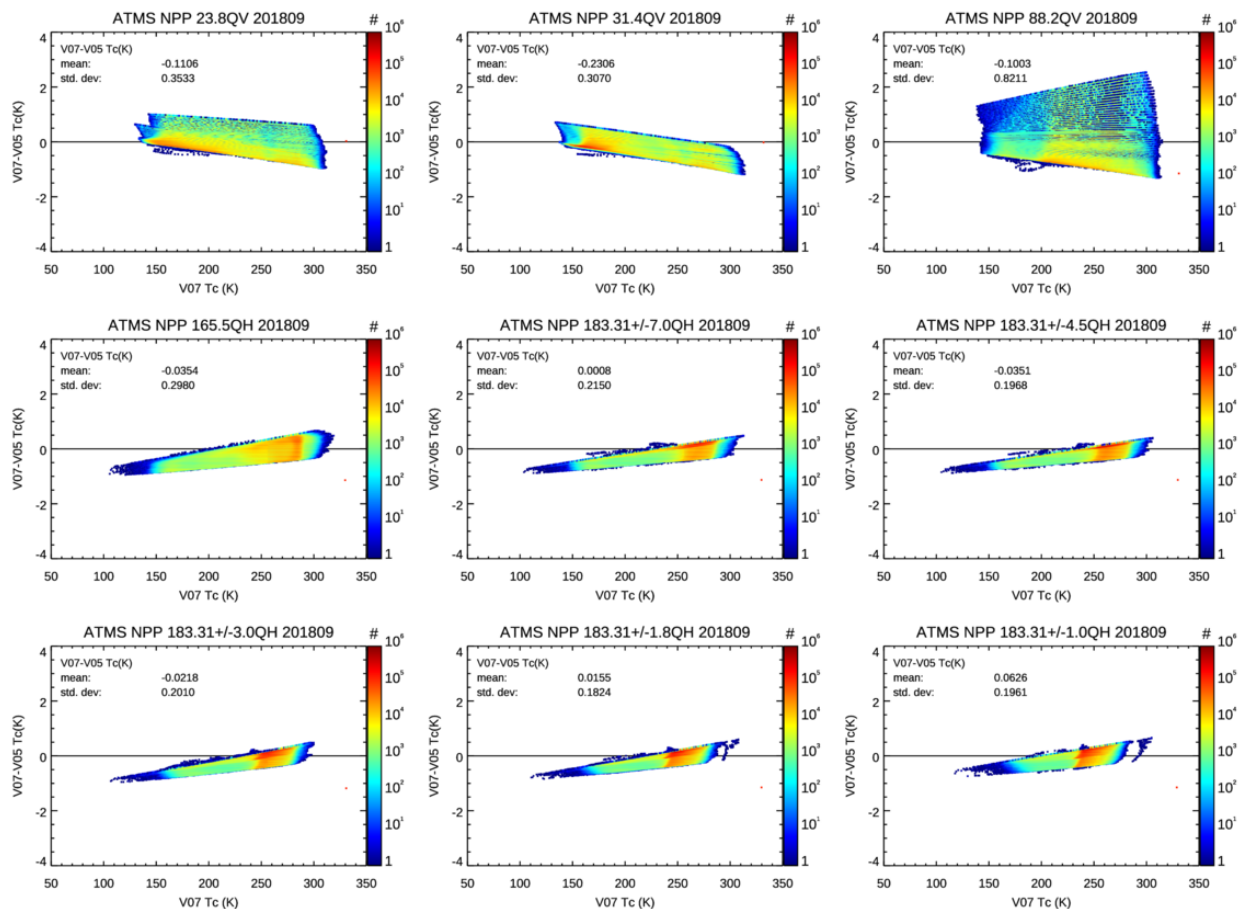




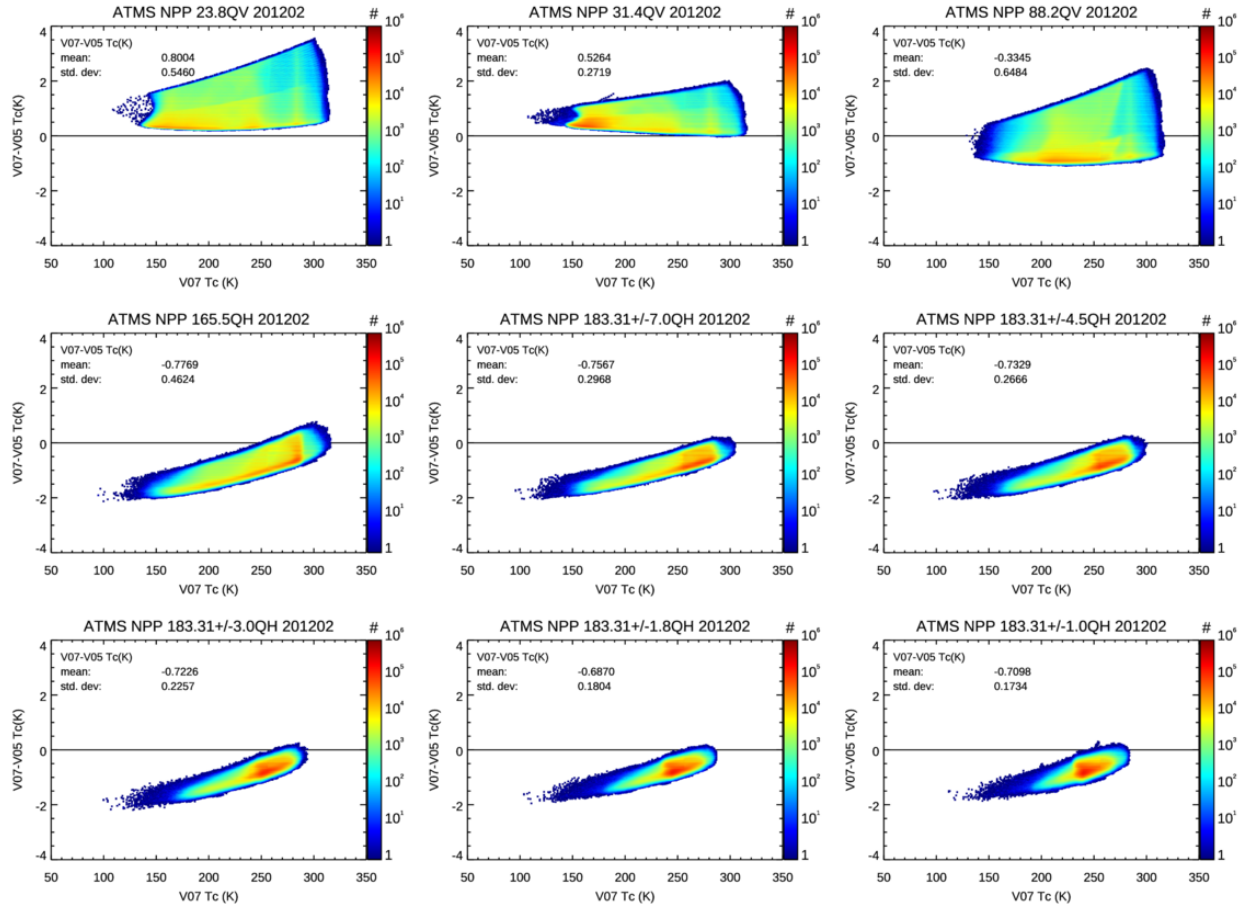
**Figure 1.** Difference Between SSMIS V07 and V05 Tc as a Function of Scene Temperature

## Appendix B. ATMS NPP Level 1C V07 Release Notes

The following figures show the differences between V07 and V05 Tc for September 2018 (more recent data) and February 2012 (early mission data).



**Figure 2.** Difference Between ATMS NPP V07 and V05 Tc as a Function of Scene Temperature for September 2018



**Figure 2.** Difference Between ATMS NPP V07 and V05 Tc as a Function of Scene Temperature for February 2012

## Acronym List

Below are the acronyms and abbreviations used in this document.

AMSR2	Advanced Microwave Scanning Radiometer 2
AMSRE	Advanced Microwave Scanning Radiometer Earth Observing System
AMSUB	Advanced Microwave Sounding Unit – B
ATMS	Advanced Technology Microwave Sounder
ECMWF	European Centre for Medium-Range Weather Forecasts
GCOM-W1	Global Change Observation Mission – Water
ERA5	ECMWF Reanalysis V5
GDAS	Global Data Assimilation System
GMI	GPM Microwave Imager
GPM	Global Precipitation Measurement
L1B	Level 1B
METOP-A	Meteorological Operational Satellite – A
MHS	Microwave Humidity Sounder
MSPPS	Microwave Surface and Precipitation Products System
NOAA	National Oceanic and Atmospheric Administration
NPP	National Polar-Orbiting Partnership
ORB	Orbital
SAPHIR	Sondeur Atmospherique du Profil d’Humidite Intertropicale par Radiometrie
SDR	Sensor Data Record
SSMI	Special Sensor Microwave Imager
SSMIS	Special Sensor Microwave Imager/Sounder
Tb	Brightness Temperature
Tc	Intercalibrated Brightness Temperature
TIROS	Television Infrared Observation Satellites
TMI	TRMM Microwave Imager
TOVS	TIROS Operational Vertical Sounder
TRMM	Tropical Rainfall Measuring Mission
V05, V07	Version 5, Version 07
V1, V2	Version 1, Version 2
X-CAL	GPM Intercalibration Working Group